REMARKS/ARGUMENTS

Claims 1-5 are pending in the application.

In Paragraph 2 on page 2 of the Office Action, claim 1 is rejected under 35 U.S.C. § 102(b) as being anticipated by JP-02-221184 of Ito et al. In Paragraph 4 on page 3 of the Office Action, claims 2 and 4 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ito et al. in view of JP-09175889 of Yamagishi et al. and JP-08-143392 of Nagai et al. In Paragraph 5 on page 4 of the Office Action, claims 3 and 5 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ito and further in view of JP-07-133187 of Higo. These rejections are respectfully traversed.

Addressing first the rejection of claim 1, such claim sets forth the feature in accordance with the present invention that in a method for growing a semiconductor single crystal according to the Czochralski (Cz) method utilizing an apparatus, the apparatus is provided with subsidiary heating means below the crucible and the single crystal is pulled with subsidiary heating of the crucible by the subsidiary heating means in addition to the heating by the heater surrounding the crucible for a period after a ratio of a weight of the growing crystal during the pulling of the crystal relative to a weight of raw material melt before the growing becomes 60% or more.

In the case of conventional single crystal pulling apparatus using the Cz method as shown in Fig. 3 of the application, and as described at line 18 of page 3 through line 20 of page 4 of the specification, heating from the lateral direction only by the heater surrounding the crucible tends to become insufficient in terms of heating quantity. In particular, in the period of pulling of the latter half of the straight body of a single crystal ingot or after the single crystal ingot is detached, the heat receiving area from the lateral direction is decreased, because the melt

becomes shallow, and therefore the heating efficiency is decreased. As a result, a phenomena of solidification of the melt frequently occurs. Therefore, the pulling of the single crystal becomes impossible, a stress is applied to the crucible, and cracks may occur in the crucible. Alternatively, and as described at lines 11-24 of page 5 of the specification, the crucible may be deformed due to elevated temperatures.

On the other hand, and as described at line 26 of page 8 through line 6 of page 10 of the specification and elsewhere, and as shown in Fig. 2, if the crucible is subsidiarily heated from below for a period after a ratio of a weight of the growing crystal relative to a weight of initial raw material melt before the growing becomes 60% or more, where solidification of the remaining melt becomes likely to occur, it becomes possible to efficiently supplement heat to the crucible from below for a wide area, and deformation or the like of the crucible are prevented. As a result, it becomes possible to pull a crystal up to a high single crystal formation ratio even by using a crucible having a large diameter.

The features in accordance with the invention are set forth in claim 1 which recites "subsidiarily heating the crucible by the subsidiary heating means in addition to the heating by the heater surrounding the crucible for a period after a ratio of a weight of the growing crystal during the pulling of the crystal relative to a weight of raw material melt before the growing becomes 60% or more."

In rejecting claim 1 as anticipated by Ito et al., the Office Action points out that Ito discloses that side heaters (3) and bottom heaters (4) are used in the heating process and the heaters are powered as shown by Fig. 2 before the pulling of the crystal has used more than 60% of the raw material melt. However, Ito, as described in the "PURPOSE" section of the Abstract, merely teaches to melt raw materials by controlling the side heater and the bottom heater independently in order to melt crystal raw material in the crucible rapidly and effectively. Also, Fig. 2 of Ito simply suggests that an apparatus having side heaters and bottom heaters

(Fig. 1) can reduce the time to melt the raw material, compared to conventional apparatus having only side heaters as shown in Figs. 5 and 6. That is, Ito reduces the time of melt by heating the solid raw material charged in a crucible by the side heater and bottom heater before crystal growing, but there is no teaching or suggestion at all regarding controlling each heater as in the case of the present invention, when the crystal is growing after melting the solid material.

On the other hand, the invention defined by claim 1 is that subsidiary heating means below the crucible is used after a ratio of a weight of growing crystal becomes 60% or more relative to a weight of initial raw material melt, i.e., after 60% or more of raw material melt was used, which is completely different from Ito's process in which side and bottom heaters are powered before the pulling of the crystal has used more than 60% of the raw material melt, as pointed out in the Office Action.

More specifically, Ito merely teaches use of a side heater and a bottom heater (subsidiary heater) to melt the initial raw material, and this is completely different from claim 1 of the present application in which a subsidiary heater is used during the latter half of the single crystal growing after melting. Accordingly, the invention as defined in claim 1 clearly distinguishes patentably over Ito et al.

In addition, Ito neither teaches nor suggests the use of the bottom heater during the crystal growing, and problems such as interruption of pulling, cracking of the crucible and the like, which are caused by solidification of melt reduced in the latter half of the growing. Therefore, it is clear that Ito cannot provide motivation for the present invention.

Claim 1 of the present application recites "after a ratio of a weight of the growing crystal during the pulling of the crystal relative to a weight of raw material melt before the growing becomes 60% or more" (emphasis added). This should not be misunderstood as meaning that in the case of the present invention, the raw

material is heated by the side heater and the subsidiary heater before the raw material melt is used 60% or more, so that the present invention is the same as Ito. Rather, the present invention has the feature that heating is performed by the side heater and the subsidiary heater after a weight of the growing crystal becomes 60% or more relative to a weight of raw material (initial raw material) before growing.

As described in the Abstract thereof, Yamagishi describes production of a single crystal by a single crystal pulling apparatus which has a main heater 7 and a sub-heater 10 laterally and below the crucible, that enable the vertical motion to keep the thermal environment of the semiconductor melt constant. However, Yamagishi does not teach or suggest that a subsidiary heater be used after a ratio of a weight of the growing crystal relative to a weight of raw material melt before the growing becomes 60% or more, interruption of pulling caused by solidification of melt reduced in the latter half of the growing or cracks of the crucible. Therefore, it is clear that Yamagishi cannot provide motivation for the present invention.

As described in the Abstract thereof, Nagai describes installation, at the outside of a feed tube, of a sensor capable of sensing the amount of material retained in a feeder for supplying raw material. However, Nagai does not teach or suggest installing subsidiary heating means below the crucible, or the problems of the present application such as interruption of pulling or cracking of the crucible, which are caused by solidification of the melt that is reduced in the latter half of the growing. Therefore, it is clear that Nagai can provide no motivation for the present invention.

As described in the Abstract thereof, Higo teaches calculating the temperature gradient by measuring the value of the melt surface temperature by radiation thermometers 6 and 7. However, such reference does not teach or suggest providing subsidiary heating, or discuss the problems such as interruption of the pulling or cracking of the crucible, which are caused by solidification of melt

reduced in the latter half of the growing. It is therefore clear that Higo cannot provide motivation for the present invention.

As described above, Yamagishi, Nagai and Higo do not teach or suggest the main features in accordance with the present invention, such as using subsidiary heating after the weight of the pulling crystal becomes 60% or more relative to the weight of the initial raw material melt before the growing, or the problems such as interruption of the pulling or cracking of the crucible, which are caused by solidification of melt reduced in the latter half of the growing. Claim 1, and dependent claims 2, 3 and 5 which include further limitations in accordance with the present invention, cannot be derived from Yamagishi, Nagai and Higo, in addition to Ito.

Claim 4 is rejected in the Office Action as being unpatentable over Ito in view of Yamagishi and Nagai. However, claim 4 includes the feature in accordance with the present invention that, in a method for growing a semiconductor single crystal according to the Cz method utilizing an apparatus, after a grown single crystal is detached from the melt and taken out from the apparatus for producing a crystal, a raw material is newly added to the raw material remaining in the crucible and is melted, and when a seed crystal is brought into contact with the melt to pull a single crystal again, the crucible is heated by the heater surrounding the crucible and the subsidiary heating means so that the raw material melt should not be solidified, at least for a period from the point of detachment of the single crystal ingot to the point of complete melting of the raw material in the crucible, including the raw material newly added thereto. As described at line 20 of page 20 through line 5 of page 21 of the present application, when raw material is additionally introduced in the multi-pulling, if the raw material melt completely solidifies in the crucible, a stress is applied to the crucible by the volume change at the time of solidification, and the crucible may crack.

Therefore, and in accordance with the present invention, the crucible is heated also by the subsidiary heating means for a period from the point of the detachment of the single crystal ingot to the point of complete melting of the raw material in the crucible, including the raw material newly added thereto, thereby preventing solidification of melt after the single crystal ingot is detached.

As previously described, Ito describes heating raw materials rapidly and effectively by side heaters and bottom heaters during melting of the raw materials charged into the crucible before the crystal pulling. However, such reference does not teach or suggest multi-pulling, but merely teaches that heating by both heaters is applied to the case of initial melting of raw material charged into the crucible 2 in advance, as shown in Fig. 3 thereof.

Also, Yamagishi discloses the apparatus as having side heaters and bottom heaters but does not teach or suggest multi-pulling at all.

Also, Nagai teaches that in continuous charging, solid raw material is recharged by the feeder when the melt in the crucible is reduced. However, such reference does not teach or suggest providing a subsidiary heater below the crucible.

The various cited references cannot be combined so as to arrive at the present invention. None of them teaches or suggests the feature, in claim 4 for example, that in the multi-pulling, the crucible is heated by the side heater and the subsidiary heater for a period from the point of the detachment of the single crystal ingot to the point of completion of melting of the raw material in the crucible, including the raw material newly added thereto, or even the problem of the present invention that at the time of additional introduction of the raw material into the multi-pulling, a stress is applied to the crucible by solidification of the raw material in the crucible, and thereby the crucible may crack. Accordingly, one of ordinary skill in the art could not arrive at the present invention, as defined in claim 4, from an attempted combination of the references.

In conclusion, claims 1-5 are submitted to clearly distinguish patentably over the prior art as described above. Therefore, reconsideration and allowance are respectfully requested.

In view of the foregoing, it is respectfully submitted that the application is in condition for allowance. Reexamination and reconsideration of the application are requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California telephone number (213) 337-6742 to discuss the steps necessary for placing the application in condition for allowance.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1314.

Respectfully submitted,
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